Synopsis

Title of the Thesis	:	**Observational Aspects of Core Collapse Supernovae**
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Degree Registered	:	**Ph.D**
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1 Introduction

The discovery of several bright supernovae (SNe) in recent years has evoked a great deal of interest in these objects. The study of these objects are of importance not only as probes to the end stages of stellar evolution, but also as probes for cosmology. Though the basic classification of supernovae was restricted to type I and type II, pecularities became apparent over the last two decades that have been confirmed into new classes, currently designated as types Ia, Ib, Ic, IIL, IIP, IIn and IIb. Diversity in the behaviour of supernovae within a class has also become apparent, such as photometric and spectroscopic sequence in type Ia, and the existence of the super-luminous ‚Äòhypernovae‚Äô, which, at times are found to be associated with GRB events. Core collapse supernovae are the end stages of most stars, more massive than ~ 8 $M_{\odot}$. As such, they provide a key test of stellar evolution. Further, they play a major role in driving the chemical and dynamical evolution of galaxies, and have also been proposed to be major contibutors to dust epochs when the Universe was still young. SNe explosions provide unique natural laboratories for studying, in real time, the physics of a variety of combustion, hydrodynamic, nuclear and atomic processes. All subclasses of SNe, except for type Ia, are core collapse events. The differences in the observed properties of the various subclasses, and even within a single subclass, may be attributed to the progenitor mass, metallicity and environment. The light curve and the spectral development would enable obtaining certain critical parameters related to the progenitor. It is hence important to study individual SNe events. The aim of this work is to (a) study the individual objects in detail and obtain critical parameters such as the radioactive Nickel mass ejected during the explosion, the mass of the ejected material, velocity with which the material has been ejected, the explosion energy and the distance to the supernova; (b) estimate progenitor mass and radius; (c) group the individual events according to certain common properties and inter-compare the properties of the various groups to arrive at a possible evolutionary sequence of the progenitors.

2 Thesis

This thesis consists of 6 chapters.

Chapter 1 gives a general introduction to the evolution of massive stars and supernovae.

Chapter 2 describes the telescope and instrument, observations and reduction procedures. All data were obtained using the 2m Himalayan Chandra Telescope (HCT), Hanle, India. The technical details of telescope and instrument are given in the chapter. This chapter also discusses in detail the various techniques used in photometric and spectroscopic data reductions.

Chapter 3 discusses the properties of Type IIP supernovae with a detailed study of SN 2004A and SN 2008in. The distances to the supernovae are estimated using the Standard Candle Method (SCM) (Hamuy & Pinto, 2002) and the Expanding Photosphere Method (EPM)(Krishner & Kwan, 1974, 1975, Hamuy et al. 2001) . In addition, the explosion energy, radius of progenitor, the nickel mass and the mass ejected during the explosion are estimated using the observed light curves and the spectra (Hamuy 2003, Elmahamdi 2003, Litvinova & Nadyozhin 1985). The progenitor mass is also estimated based on the estimate of the ejected mass.

Chapter 4 describes the evolution of the Type IIn supernova SN2005kd, which is characterized by narrow emission lines in the early spectra. Some Type IIn supernovae show a plateau phase in the light curve, and SN 2005kd is of this kind. The narrow emission lines in the spectra show that the SN ejecta interacted with the pre-supernova circumstellar material that is a result of mass loss from the progenitor during its evolution.

Chapter 5 discusses the properties of stripped envelope core collapse supernovae using the observations of type Ib/c supernovae SN 2006jc, SN 2007ru, and SN 2009jf. SN 2006jc was found to be peculiar, with narrow He I emission lines arising due to the SN ejecta interaction with a helium enriched pre-supernova circumstellar material. SN 2007ru shows very broad lines in the spectra indicating a velocity of 20,000 kms^{-1}. The light curve evolution of SN 2007ru indicates a fast rise time and post-maximum decline more rapid than other broad-line Ic supernovae. The light curves of SN 2009jf are broad, with slow decline, indicating the presence of massive ejecta. He I line is identified with velocity of 16,000 km^{-1}.

The photometric and spectroscopic evolution of all the above SNe are described in detail and compared with other similar supernovae. The various physical parameters related to the explosion and progenitors of SNe are also estimated.

Chapter 6 is devoted to conclusions and future plans for the work in this thesis.

3 References

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2) Hamuy et. al., 2001, ApJ, 558, 615H.
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4 PhD thesis is based on the following publications

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2) *Optical photometry and spectroscopy of the Type Ibn supernova SN 2006jc until the onset of dust formation*, Anupama G. C., Sahu D. K., **Gurugubelli U. K.**, Prabhu T. P., Tominaga N., Tanaka M., and Nomoto K. 2009, MNRAS, 392, 894A

3) *The Peculiar Type Ib Supernova 2006jc: A WCO Wolf-Rayet Star Explosion*, Tominaga N., Limongi M., Suzuki T., Tanaka M., Nomoto K., Maeda K., Chieffi A., Tornambe A., Minezaki T., Yoshii Y., Sakon I., Wada T., Ohyama Y., Tanabe T., Kaneda H., Onaka T., Nozawa T., Kozasa T., Kawabata K. S., Anupama G. C., Sahu D. K., **Gurugubelli U. K.**, Prabhu T. P., and Deng J., 2008, ApJ, 687, 1208.

4) *The Broad-Line Type Ic Supernova SN 2007ru: Adding to the Diversity of Type Ic Supernovae*, Sahu D. K., Tanaka M., Anupama G. C., **Gurugubelli U. K.**, and Nomoto K. 2009, ApJ, 697, 676S

5) *Optical Studies of the type Ib supernova SN 2009jf*, Sahu D. K., **Gurugubelli U. K.**, Anupama G. C., and Nomoto K., 2010 MNRAS. Submitted.

6) *Optical and radio studies of type IIn supernova SN 2005kd*, **Gurugubelli U.K.**, Anupama G. C., Kantharia N.G., and Sahu D. K. (in preparation)

7) *Photometric and spectroscopic studies of type II-P supernova SN 2008in*, **Gurugubelli U.K.**, Anupama, G.C., Sahu, D.K. (in preparation).